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in the morning, haze all the forenoon; the barometer fell 2.$^{mil.}$ 74 between the 3rd and 4th, and the temperature rose by 0·42 C.; prevailing wind, south-south-west. At the Great St. Bernard's—mist, morning and evening of the 4th. In the night, between the 3rd and 4th, a thunderstorm with rain; barometer fell 2 millimetres. The highest temperature of the month was on the 3rd, 11° 24 C.; prevailing wind south-west.

If the phenomena which came under my notice could be considered as representing the phenomena of the Föhn, I could not avoid concluding that this wind was essentially similar to our south-west Atlantic winds, and my subsequent perusal of the various essays on the subject in the "Archives des Sciences" rendered this conclusion unquestionable.

In recent times it has become the fashion among a great number of geologists to ascribe to ice the principal agency in modifying the features of the earth's surface. Glaciers are invoked to perform every kind of denuding work, from the transport of a grain of sand to the rounding, rending, and sculpturing of mountain masses. At the present day, in Switzerland and Savoy, this work is partly performed by atmospheric action, gravity, and the moving force of water both in its liquid and solid state. In order that water should operate almost exclusively in the solid state, the glaciers must have had, according to glacialists, a much greater extension during comparatively recent geological epochs than at present. The necessity for appealing to cosmical changes was supposed to be obviated by the theory of the Föhn, which ascribes to this wind an African desert origin. Evidence has been put forward to show that the Sahara was submerged up to a comparatively recent date, and hence it was concluded that during the period of its submergence no Föhn could have existed. To the warm breath of Föhn is attributed the retrogression of the glaciers to their present positions and dimensions.

But if the Föhn is proved to have no connexion with the great African desert, this theory of the regression of Alpine glaciers must be abandoned.

LVI.—Report on the Researches of Herr Cohnheim on Inflammation and Suppuration. By J. M. Purser, M. B.

[Read July 12, 1869.]

The researches of Professor Cohnheim on suppuration are of great importance, and have excited a very unusual amount of interest. The corpuscles of pus have long been acknowledged by microscopists to be morphologically indistinguishable from the white cells of the blood; but they were supposed to originate either by proliferation of the cells of the inflamed part, or to arise spontaneously in a formative fluid or blastema poured out from the blood. The point of Cohnheim's theory

is, that the pus corpuscles are not only similar in form to the white blood cells, but that they actually are blood cells which have, aided by certain conditions of the circulation in inflamed parts, passed through the uninjured walls of the blood vessels and become free.

The following is a short sketch of the observations on which this theory is based. When the cornea was made to inflame, the suppuration was found always to begin at the edge, and to travel towards the centre, and this whether the irritant was applied to the central parts or to the periphery. Now, the cornea is a tissue which contains no blood vessels of its own, but whose borders join on to vascular parts. Furthermore, at all stages of the suppurative process the cornea cells could be seen unaltered in the midst of the pus cells, and the former never showed any sign of proliferation, or of undergoing change into the latter.

Lastly, when coloured substances in a minute state of division were injected into the blood, they were taken up by the white blood cells, which were by this means marked, and could be traced in their wanderings through the body. If, in an animal thus treated, a keratitis was excited, among the pus cells found in the cornea were always a number which contained coloured particles, showing that some, at all events, of the pus cells had been at a former time blood corpuscles.

At this point it became necessary to observe the process of inflammation in some vascular part where the passage of the blood cells through the walls of the vessels might be seen, if such a process did really occur. As the subject of his observations for this purpose Cohnheim chose the mesentery, or transparent membrane which binds the intestine to the back wall of the abdomen, and in which the vessels going to and returning from the intestine are found. The animals used were frogs. A few experiments made also on young rabbits and kittens, although attended with much difficulty, and much more imperfect in their results than those performed on frogs, showed, nevertheless, that the phenomena of the inflammatory process were essentially the same in warm as in cold blooded animals. The method of preparation adopted in the case of the frog is as follows. The animal is first poisoned with a small dose of curara, which prevents all voluntary movement, paralysing the peripheral extremities of the motor nerves, while the circulation goes on unimpaired. When the frog becomes motionless, a small opening is made through the side into the abdomen, and through this the intestine is drawn out. The animal is then laid on his back on a large glass plate, on which a small disc of glass, surrounded by a narrow ring of cork, has been cemented with Canada balsam. Over this disc the mesentery is laid; and the intestine which comes to lie on the cork ring is attached to this by a few small pins, so as to prevent displacement of the object by the peristaltic movements of the intestinal muscular fibres. The mesentery may or may not be covered with a piece of thin glass—Cohnheim prefers to examine it uncovered; and I have found it best to do so, for the sharp edge of the covering glass is very apt to injure some of the small blood vessels of the delicate mesenteric tissue, and to cause hæmorrhage, which completely destroys the object. When thus

arranged, the glass plate is laid on the stage of the microscope, and the mesentery examined with lenses of different powers, according as is found necessary. It is not needful to apply any irritant to the mesentery, for the mere contact with the air is sufficient to excite a severe suppurative peritonitis; and as the animal often lives and the circulation goes on steadily for upwards of forty-eight hours, the inflammation can be watched with great facility in all its stages.

In a mesentery so exposed the following phenomena are observed. *The blood vessels dilate.* The arteries dilate at first, and with considerable rapidity; next the veins, more slowly. These vessels are sometimes enlarged to double their former diameter. The capillaries dilate less; their apparent increase in size being chiefly due to their containing a greater number of red corpuscles, and so becoming more distinct. Coincidently with this vascular dilatation *a slowing of the course of the blood* is seen to occur, and the white corpuscles appear more numerously in the peripheral layers of blood in both arteries and veins, but more particularly in the latter. The white corpuscles go on accumulating along the sides of the veins, and become stationary, adhering to the vascular wall, till at last *the inner surface of each vein is lined by a continuous layer of white corpuscles*, forming a secondary tube, in the centre of which the ordinary current continues to flow. Shortly after this small projections are seen on the outer surface of the veins, and these gradually enlarge till they each attain the size of a white blood corpuscle, which they further resemble in colour and granular appearance. At last they are attached to the wall of the vein merely by a narrow stalk; and from the side remote from the vessel they begin to throw out finger-like processes and to perform other amæboid movements, till at length the stalk separates from the vein, and the corpuscle becomes free, moves away, a perfect pus corpuscle, into the tissue of the mesentery. This *emigration of corpuscles* goes on from all sides of the vein till the vessel is surrounded by a thick mass of cells which have passed out through its walls, and which were white blood cells, but which, now they are extravasated in an inflamed tissue, must be called pus or exudation cells. They undergo the most remarkable alterations of form, and spread themselves through the tissue and over the surface of the mesentery by virtue of the power of spontaneous motion enjoyed by all masses of living protoplasma. In the capillaries during this time the circulation is very irregular. In some vessels it continues to flow unintermittingly in a continuous stream. From such a capillary no emigration of corpuscles takes place. In other vessels the current stagnates for a time, and again goes on. In others the stagnation is permanent, and in some the current varies from time to time both in direction and rapidity. In those vessels in which a stoppage of the blood flow occurs, whether temporary or permanent, the exit of the corpuscles can be observed with great clearness. The white cells, which when in circulation always preserve the spherical shape, when they come to rest inside the vessel begin to change in form, and after a little time they are seen to pass through the wall of the capillary just as they do through that

of the vein. In the case of the capillary the last doubt as to the identity of cells within and those without the vessel is removed; for the vascular wall is here so thin as to allow a white corpuscle to be partly within and partly without at the same time, and a gradual transference of the substance of the corpuscle from the part within to the part without can be watched till at last the corpuscle has wholly passed through, and moves off to make way for others. Through the capillary walls the red corpuscles also pass in considerable number; and there are few more remarkable objects than a capillary in which the blood has been for some time stagnant, and in which a number of red corpuscles have got halfway through the wall when the circulation recommences. The parts of the corpuscles within are then agitated by the current, and sometimes actually torn away from their other halves which have got through, and remain motionless outside the vessel.

The exit of corpuscles through the walls of the arteries is insignificant, and seldom occurs except when a dilatation followed by a constriction of the vessel allows a temporary or partial stasis of the blood to occur. Red corpuscles never pass through the walls of the arteries or veins.

After some hours the mesentery becomes cloudy and opaque, from the number of cellular bodies mixed with fluid exudation from the vessels, which are spread out on its surface or imbedded in its substance; the appearances are those of well-marked suppurative peritonitis, and any one not knowing whence the cells are derived would have no hesitation in calling them pus corpuscles.

It appears from this description that the main condition for the emigration of white corpuscles is, that they should have come to rest at all events for a short time while within the vessels. The white corpuscles, as is known, are composed of protoplasma, that peculiar substance which forms the mass of all living cells, whether animal or vegetable. This protoplasma, among many remarkable properties, possesses two which are of great importance in our present subject—namely, irritability and the power of spontaneous movement. While the blood is circulating, and while the corpuscles are being perpetually rubbed against each other and against the sides of the vessels, the protoplasma is kept in a condition of tetanus; and, contracting so as to occupy the smallest possible space, it maintains the spherical shape of the ordinarily described white blood cell, and in this condition it is incapable of passing through the walls of the vessels. But no sooner do the corpuscles come to rest, and get relief from the perpetual irritation of friction, than they begin to move, throwing out processes and changing in shape just as some infusorial animals are seen to do; hence, these movements have been described and are usually known under the title of the *amæboid movements* of the corpuscles. The white cells of the blood further resemble the amæba in their power of taking up into their substance minute particles of matter brought in contact with them; and when the corpuscles are thus fed, as it were, with materials easily recognisable, their passage through the vascular walls and their wan-

derings throughout the body are much more easily followed than when the movements of the normal corpuscles are observed. I have repeatedly injected milk, carmine, and aniline blue into the lymphatic spaces of frogs, and found the substance injected in the course of a few hours taken up in great quantity by the blood corpuscles. Now, it is by this power of changing shape and performing spontaneous movements that the white corpuscles appear to be able to leave the vessels. The veins and arteries are formed of coats, all of which, except the internal, are composed mainly of connective tissue; for, as Cohnheim observes, even the muscular coat may be considered as formed of connective tissue, containing set in it a greater or less abundance of muscular fibre cells. Now, we know that the connective tissues, with the exception of cartilage, are full of spaces through which the corpuscles possessed of amæboid powers of locomotion can freely pass. But the internal coat of the larger vessels is composed of a layer of flat epithelial cells united at their edges, and a similar layer forms the only tunic of the smaller capillaries. Now, if this were a perfectly continuous layer, it would be difficult to explain the passage through it of the white cells; for we have no reason to believe that these bodies have any power of making a way for themselves, but only of travelling through passages already formed. But this difficulty is removed by a recent anatomical discovery which shows that the internal vascular tunic is not absolutely continuous, but that between the cells small circular spaces exist, called stomata, numerous in the veins and capillaries, and more sparingly present in the arteries, and which are readily seen after an injection of the vessels with nitrate of silver, a reagent which brings out with great distinctness the outlines of the epithelial cells. Through these stomata Cohnheim, apparently with much reason, supposes the white corpuscles to pass.

With regard to the emigration of the red corpuscles through the capillary walls much difficulty exists. The red discs are generally believed to have no power of spontaneous movement, and Cohnheim supposes that they are forced out mechanically through the stomata, enlarged by the previous passage through them of the white cells, the increased pressure in the capillaries being brought about by the partial stasis of blood in the veins. The red corpuscles pass certainly in great numbers through the capillaries of a part in which the venous circulation is impeded, as may be seen in the web of the frog's foot after ligature of the crural vein; but the pressure must be exerted in the direction of the axis of the vessel, and it is difficult to conceive how this could act on the corpuscles so as to force them to move through the walls of the vessel in a direction at right angles to that of the force acting on them. Professor Bastian, from these and some other considerations, prefers to attribute to the red corpuscles powers of spontaneous movement, and to believe that the red as well as the white corpuscles leave the vessels through powers inherent in themselves, and independently of mechanical pressure. I have never myself seen any

spontaneous movement performed by the red corpuscles, whether within or without the vessels, but at the same time I think that Cohnheim's theory does not account for the phenomenon under consideration. I must hence leave the explanation of the fact for the future. Of the fact itself there cannot be a shadow of doubt.

Now, with regard to the phenomena just described as observed by Cohnheim in the exposed mesentery, I may say in one word that I have confirmed their accuracy in every particular; I have seen and measured the dilatation of the vessels; I have observed the retardation of the blood flow, the stasis in the capillaries, the accumulation of white blood cells along the inner surface of the veins, and the exit of the corpuscles through the vascular walls; while I have never seen a pus cell formed from any of the connective tissue or epithelial elements of the mesentery or blood vessels. But there is one point untouched upon by Cohnheim and almost all other writers on this subject, that is the part played in inflammation by the lymphatic vessels and their contents. The lymphatics in the mesentery of the frog run either as sheaths surrounding, or as separate tubes immediately apposed to the blood vessels. Now, on exposing the mesentery, these lymphatic vessels are seen to contain clear lymph with leucocytes, indistinguishable from those of blood or pus, floating in it in variable number. Soon the circulation of lymph becomes languid, and stops, while the corpuscles adhere about the outer side of the blood vessels, and perform amæboid movements; so that the vessels are often at an early period studded over with corpuscles which have not passed out from their interior. The number of these corpuscles is quite insignificant, compared to the number of those which subsequently pass out from the blood; but it will be observed always that those veins which are surrounded by lymphatic sheaths are more thickly covered with pus corpuscles than those which have no space about them—a fact the explanation of which, I think, must be mainly sought in the lymphatic space, which, by affording room, facilitates the exit of corpuscles through the walls of the vessels.

Very shortly after exposure, if the *surface* of the mesentery be examined, corpuscles will be seen floating in the fluid which moistens the membrane. These, I think, float out from the lymphatic spaces under the skin; for on making a small opening in the skin, and examining the fluid which flows from the wound, I have always found it to contain leucocytes in greater or less number. The peritoneal fluid also often contains white cells. The observations on the tongue of the frog gave results precisely similar to those made on the mesentery. All the pus was derived from the blood, the cells of the tongue remaining throughout the inflammatory process unconcerned in the suppuration.

These observations of Cohnheim have been repeated, and in all essential particulars confirmed, by a great number of observers. The only attempt at a serious refutation of the fact of the emigration of the blood cells was made a few months ago by Professor Balogh, of Pesth; but his objections are so futile, and his own observations so manifestly

erroneous, that it would be mere waste of time to give any lengthened consideration to his paper.

That by the experiments I have detailed one mode of origin of pus corpuscles is established beyond question, I think must be admitted; but at the same time I think it would be premature to affirm that this is the only way in which these bodies arise. Still we must allow that Cohnheim made a most remarkable and fruitful discovery, when he found that the white corpuscles can traverse the walls of the vessels without injury to the latter.

The importance of this discovery is not confined to the process of suppuration only; for there can be no doubt that, under favourable circumstances, the extravasated corpuscles may undergo development, and take part in the formation of tissues or new growths; and already observations and experiments have been made, showing that in the healing of wounds and other processes besides those of suppuration the emigrated white blood cells play a most important part. In several cases, too, where great difficulty was formerly experienced in accounting for the origin of pus by deriving it from the pre-existing cells of the inflamed part, the theory of Cohnheim offers welcome assistance. Pneumonia, in which the air vesicles of the lungs become filled with exudation, composed mainly of pus cells, is such a case. Quite recently, Axel Key has proved, by the injection into the blood of coloured substances, so as to mark the white corpuscles, and examination of the exudation in a subsequently excited pneumonia, that the pus corpuscles in the latter contained coloured particles, and were, therefore, derived from the blood. The great abundance of *capillary* vessels about the air spaces of the lung will account for the well-known rusty colour of the sputum in pneumonia.

This has long been recognised as dependent on the presence of red-blood corpuscles; and it will be remembered that through the capillary walls red as well as white corpuscles have been seen to pass.

I hope in a future communication to report on the process of inflammation in the cornea; my observations on this tissue have hitherto not given decisive results.